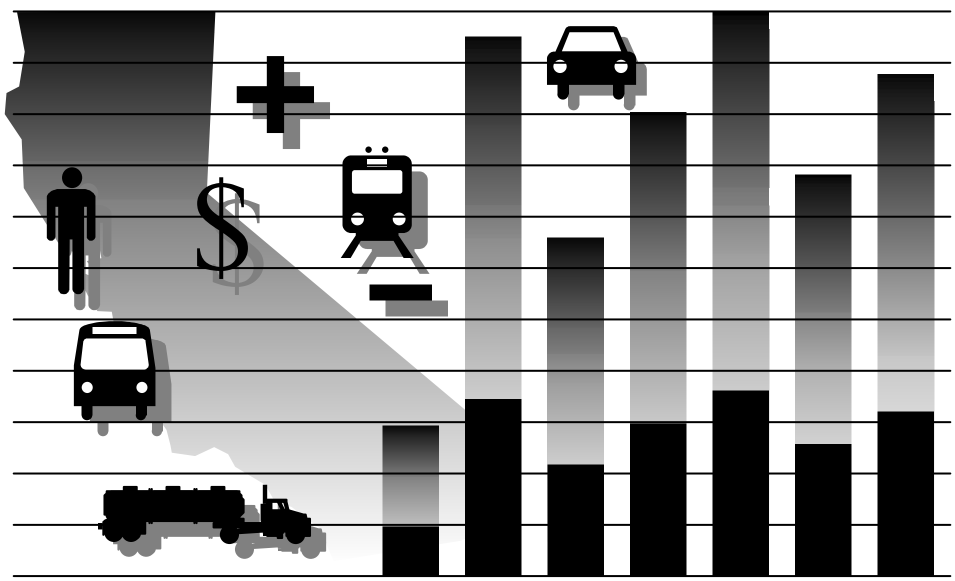
California Life-Cycle Benefit/Cost Analysis Model (Cal-B/C)

User's Guide
(Version 3.2)



System Metrics Group, Inc.

In association with
Cambridge Systematics, Inc.

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LIST OF EXHIBITS

Welcome to the User's Guide for the *California Life-Cycle Benefit/Cost Analysis Model (Cal-B/C)* Version 3.2. The California Department of Transportation (Caltrans) uses Cal-B/C to conduct investment analyses of improvement projects proposed for the interregional portion of the State Transportation Improvement Program (STIP).

Cal-B/C is a spreadsheet-based tool for preparing analyses of both highway and transit projects. Users input data defining the type, scope, and cost of projects. The model then calculates life-cycle costs, net present values, benefit/cost ratios, internal rates of return, payback periods, and annual and life-cycle benefits.

While the original model focused on capacity expansion projects, Cal-B/C Version 3.2 adds capabilities for assessing intelligent transportation system (ITS) investments and operational improvements. It builds on the latest research into the benefits of ITS sponsored by the Caltrans Division of Research and Innovation and the Federal Highway Administration's ITS Deployment Analysis System (IDAS). It also incorporates prior revisions that allow Cal-B/C to consider pavement rehabilitation projects.

This quick-start manual introduces you to important features of Cal-B/C and leads you through analyses of hypothetical projects. (Your copy of Cal-B/C may produce slightly different results from the examples due to updates in economic values.) The technical supplement to the user's guide provides details of the methodologies and analytical framework for the model. The first volume of the supplement documents the base model and the second volume documents changes made in subsequent updates.

1. USER REQUIREMENTS

At a minimum, the user of Cal-B/C should have a working knowledge of spreadsheets, particularly Microsoft Excel. To use Cal-B/C, the reader of this User's Guide must be able to navigate through a multiple-sheet workbook and understand basic principles, functions, and the terminology used when discussing spreadsheets.

The professional using the model to analyze projects should also understand life-cycle benefit-cost analysis and be able to interpret the results in a transportation planning context. The reader should refer to the User's Guide Technical Supplement to learn more about the concepts used to develop Cal-B/C.

2. OPERATING SYSTEM AND SOFTWARE REQUIREMENTS

Cal-B/C is a Microsoft Excel 2002 workbook called *Cal-BC.xlt*. The file is around 950KB in size and has been saved as a template to avoid accidental changes to the model. Although designed for a PC environment, Cal-B/C also works on an Apple Macintosh computer running Excel 2002. The computer operating system must have enough memory and hard disk space to operate Excel and Cal-B/C.

3. MODEL OVERVIEW

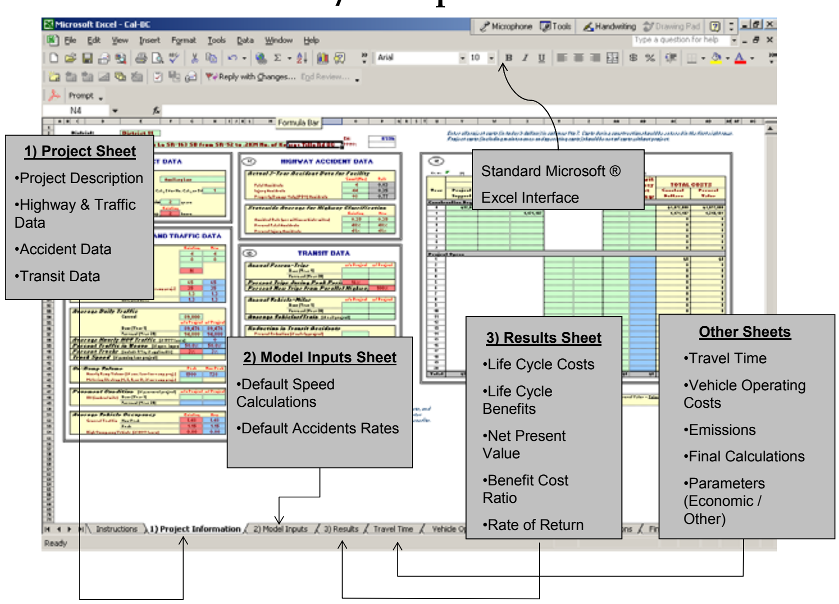
Cal-B/C is a Microsoft Excel spreadsheet that provides economic benefits and cost analysis for a range of capacity-expansion transportation projects. The model measures, in real-dollar terms, four primary categories of benefits that result from highway and transit projects:

- Travel time savings
- Vehicle operating cost savings
- Safety benefits (accident cost savings)
- Emission reductions.

Each of these benefits are estimated for a peak (or congested) period and a non-peak (or un-congested period). The distinction is intended to capture the difference in benefits during congested and free-flow conditions on the highway as well as different operating characteristics for transit at peak times of the day. It is understood that some travel demand models have set peak periods that do not necessarily correspond to the congested period on the highway. Cal-B/C can accept these data in lieu of congested period data.

The model consists of cover page and ten sheets in an Excel workbook. Users generally refer to only the first four worksheets after the cover page (including one that provides instructions and reference materials) to conduct analyses as shown in Exhibit 1. The six remaining worksheets perform calculations or store defaults and economic parameters.

Exhibit 1: Cal-B/C Graphical User Interface



Cal-B/C requires relatively few user inputs. Cells in the spreadsheets are color-coded. Green cells represent required data (i.e., users must input values in order for the model to work). Red cells provide default values, such as average vehicle occupancy, that users can change if needed. Blue cells reflect data items calculated by the model, but can be changed if more detailed data are available. Blue cells contain values that are likely to change from the base case.

The first worksheet after the cover page provides *Instructions*. The instructions include short descriptions of each step involved in performing a basic analysis and hints on how to avoid potential pitfalls.

The *Project Information* sheet is the main data-entry worksheet. Users enter descriptive information about projects, expected traffic demand, accident rates, transit data (for transit projects only), and expected project construction and operating costs. The sheet also has a button linked to a macro that allows users to run analyses for bypass and interchange projects.

Caltrans provides Districts with "District input sheets" to use for submitting project information to Headquarters. These input sheets look similar (but are not identical) to the Cal-B/C project information sheet. For each project, a District is asked to submit only relevant data using one of several input sheets tailored to a specific type of project.

The *Model Inputs* page in Cal-B/C contains information about the highway speed, volume, and accident data used in the calculation of benefits. This sheet allows users to check the highway data estimated by the model from the project information sheet and override the calculated values with project-specific information, if such information is available. Some users may have volume and speed estimates and projections from regional travel demand forecasting models. Users can use peak and off-peak period volumes and speeds from regional demand models to override the calculated values produced by Cal-B/C. The model calculates speeds using speed/volume relationships found in the 2000 Highway Capacity Manual.

The *Results* sheet presents the final investment measures as well as annualized and life-cycle benefits. The sheet allows users to include the effects of induced travel and vehicle emissions. Cal-B/C calculates induced travel benefits using consumer surplus theory. Cal-B/C summarizes analysis results on a per-project basis using several measures:

- Life-cycle costs (in millions of dollars)
- Life-cycle benefits (in millions of dollars)
- Net present value (in millions of dollars)
- Benefit/cost ratio (benefits divided by costs)
- Rate of return on investment (in percent return per year)

- Project payback period (in years).

The model also itemizes anticipated average annual benefits (in millions of dollars) and benefits for the full twenty-year life-cycle. The calculated benefits include:

- Travel time savings
- Vehicle operating cost savings
- Accident cost savings
- Emission cost savings.

Experienced users can override default parameters in the *Parameters* other calculations worksheets to produce tailored results if more detailed information is available for specific projects. The model requires inputs on only the three worksheets previously mentioned, but the parameters and detailed calculation sheets can be accessed to change default values as needed.

The *Parameters* worksheet (the last sheet in Cal-B/C) contains all the economic values and rate tables used by the model. Adjusting the economic update factor using the Gross Domestic Product (GDP) deflator changes the economic values contained in the model. Values in this sheet include the following unit costs:

<u>General Economic Values</u>
- Year of current dollars for model
- Economic update factor (using GDP deflator)
- Real discount rate

<u>Highway Operations Measures</u>
- Maximum volume-capacity (v/c) ratio
- Percent ADT in average peak hour
- Capacity per lane (general)
- Capacity per HOV lane

<u>Travel Time Values</u>
- Average hourly wage (for Transportation and Utilities industry and all industries statewide)
- Automobile, truck, and transit

<u>User Operating Costs</u>
- Fuel cost per gallon
- Non-fuel cost per mile (automobile and truck)

<u>Highway Accident Costs</u>
- Cost of a fatality
- Cost of an injury (Level A Severe, Level B Moderate, Level C Minor)
- Cost of a highway accident (fatal, injury, and PDO)
- Statewide hwy accident rates (fatal, injury, PDO)

<u>Fuel Consumption Rates</u>
- Gallons per VMT for autos and trucks

<u>Passing Lane Accident Reduction Factors</u>

Transit Accident Rates and Costs
- Fatality, injury, and PDO accidents
- Passenger train, light-rail, and bus

<u>Highway Emissions Rates</u>
- CO, NOX, PM10, SOX, and VOC
- Automobile, truck, and bus

<u>Rail Emissions Rates</u>
- CO, NOX, PM10, and VOC
- Passenger train and light-rail

<u>Emissions Costs</u>
- Urban Southern California, urban Northern California, and rural California
- Automobile, truck, and bus.

4. WORKSHEET DETAILS AND PROJECT ANALYSIS

The following sections describe the three primary Cal-B/C worksheets and walk the user through a hypothetical project. The main text in each section introduces the user to an element of the model and the project examples provide details on how to enter data.

4.1 Project Information Worksheet

The *Project Information* sheet is the main data input sheet (Exhibit 2). For most projects, this will be the only sheet needed by the user. The user needs to modify other sheets only if the user has information more specific to the project than is calculated by the model. The project information worksheet has five sections identified in Exhibit 2 and in the table below. A button is available to prepare the model to analyze a bypass road or the crossing road for an interchange project.

Section Number	Name of Section	Location of Section in Worksheet (Top Left Cell: Bottom Right Cell)
1A	Project Data	B6:I17
1B	Highway Design and Traffic Data	B19:J55
1C	Highway Accident Data	K6:Q20
1D	Transit Data	K22:Q48
1E	Project Costs	T6:AE45
	Bypass/Interchange Button	K50:Q55

4.1A Project Data

The project data input section as shown in Exhibit 3 is where the user enters the following types of information about the project:

NEW **Type of project.** The model allows the user to identify several project types including:

Highway Capacity Expansion	Transit Capacity Expansion	Operational Improvements	Transportation Management Systems (TMS)
General Highway	Passenger Rail	Auxiliary Lane	Ramp Metering
HOV Lane	Light-Rail (LRT)	Freeway Connector	Ramp Metering Signal Coordination
Passing Lane	Bus	HOV Connector	Incident Management
Interchange		HOV Drop Ramp	Traveler Information
Bypass		Off-Ramp Widening	Arterial Signal Management
Pavement		On-Ramp Widening	Transit Vehicle Location (AVL)
			Transit Vehicle Signal Priority
			Bus Rapid Transit (BRT)

The user selects this data by using a pull-down menu bar. The pull-down options become available when the user makes cell F10 the active cell. Making a cell "active" simply means putting the cursor in that particular cell. Once the cell is active a scroll bar becomes visible for the user to select on of the above project types.

Project location (e.g., Northern California Urban, Southern California Urban, or rural). The model uses this information to estimate emission benefits using emission valuations appropriate for each region.

Length of construction period determines the opening date of the project, which is assumed to occur at the end of the construction period.

Length of peak period(s) helps the model determine peak speeds. Cal-B/C uses peak speeds to estimate user costs, fuel consumption, and emissions. The length of the peak period should be input as hours of the peak. For example, if the peak period is from 6:00 AM to 8:00 AM along the segment where the project is proposed, then the user would put "2" in this input cell.

Exhibit 2: Project Information Worksheet

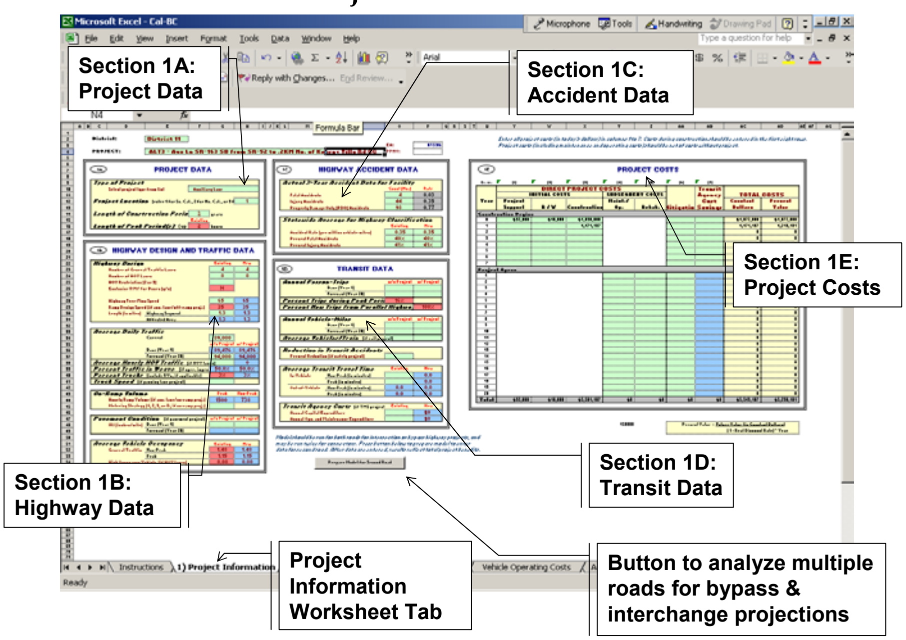
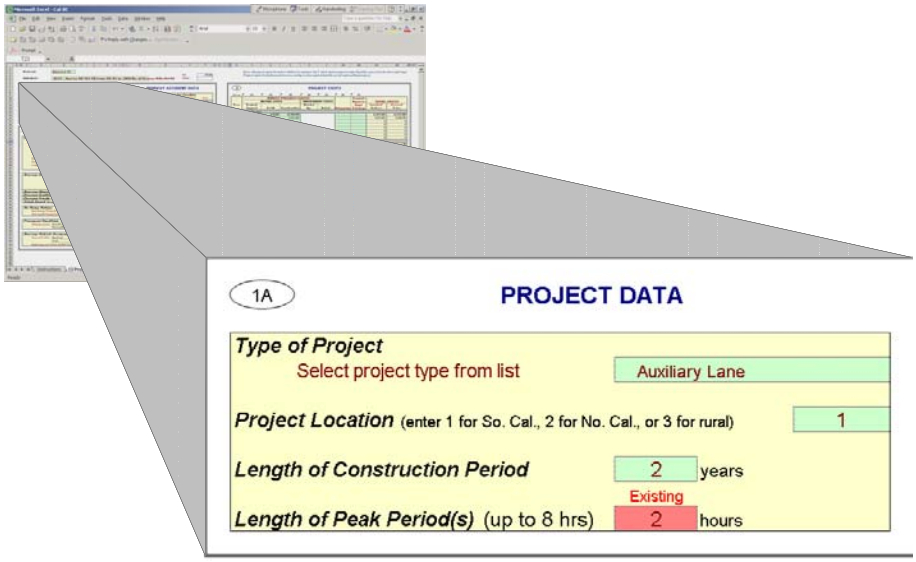


Exhibit 3: Project Information - 1A, Project Data



PROJECT EXAMPLE STEP 1: Project Information

In this project example, which will be used throughout this User's Guide, we are going to "construct" a 1.3 mile auxiliary lane along a segment of roadway containing three interchanges (i.e., 3 on-ramps and 2 off-ramps). This project was selected because auxiliary lanes are a common project type, and because this particular example points out some of the complex issues that have to be addressed in the analysis. Cal-B/C should not be viewed as a "black box". Using this tool requires making professional engineering judgments as well as the ability to interpret the outputs appropriately.

To begin the analysis, open the *Project Information* sheet (Worksheet tab "1) Project Information"). Exhibit 3 shows the *Project Data* section for our auxiliary lane. Note that green-colored cells may require data input. The red cells provide default values that the user can change.

(1) **Descriptive Project Information.** The area at the very top of the worksheet provides space to enter the District where the project is being developed, a descriptive project name, the project EA number and the project PP number (PPNO). This information is not required, but it is useful to include for identification purposes when you return later to the project.

(2) **Type of Project**. Make merged cells F10 through H10 the active selection by clicking on one of those cells. Use the scroll bar at the right to find the "Auxiliary Lane" project type. This is a required selection for any project. Not all green cells require data entry, only those green cells relevant to a particular project type. However, the user must select a project type.

(3) **Project Location**. This cell requires you to enter a "1" for Southern California urban areas, a "2" for Northern California urban areas, or a "3" for rural areas in order to determine emissions benefits for the project. Assume that our project is built in Southern California, and put a "1" in this cell. This cell tells the model which emissions tables to reference in the Emissions worksheet.

(4) **Length of Construction Period**. Enter the amount of time needed to construct the project. Assume that this auxiliary lane project will be completed in 2 years. Cal-B/C uses this cell to determine the economic impacts. This number must be a whole number. A project that will take 8 months to construct should be entered as the number "1" representing one year. A project taking 2 years and 5 months can be rounded down to 2 years or up to three years, at the user's discretion, but must be consistent with the cost data entered.

Note that he model evaluates project impacts only after the project is built. For example, a project that began construction in 2002 and that takes 3 years to complete will not cause any impacts until year 2005 when the project opens. The Year 1 impacts occur immediately after the project opens. The Year 20 impacts would occur in 2024 for this hypothetical project.

(5) **Length of Peak Period**. For our project, enter a "2" in this cell to represent a two-hour total daily peak travel period (include both AM and PM peak periods). Since we are constructing a lane in only one direction, let's assume that the peak period is one-directional (therefore, the short peak period).

The model can evaluate up to an 8-hour daily peak period. Cal-B/C estimates peak hour volumes from ADT volumes by multiplying a statewide average peak-hour percent traffic by the number of peak hours (Cal-B/C was tested and calibrated using a 5-hour peak period). For projects longer than 8-hours, the user must adjust the length of the peak period and the percent ADT in a typical peak hour in the Parameters worksheet). The peak period helps convert average daily traffic volumes (described below in Section 4.1B) into average peak and non-peak volumes and speeds. Speed is an important variable to determine travel time savings, fuel consumption, and emissions.

4.1B Highway Design and Traffic Data

This section (Section 1B), shown in Exhibit 4, is where the user inputs data about the highway components for both highway and transit projects. Most transit-specific elements are added in Section 1D of the Project Information worksheet. Here, the user enters data for the existing or "No Build" situation and for the future or "Build" situation after project completion. The following data is entered into this section of the worksheet:

Highway Design is where basic lane, design speed, and section data is input for highway projects. The data input in the highway design section includes:

- *Number of General Traffic Lanes* – The user provides the number of mainline traffic lanes along the section of roadway both for the existing condition and for any future improvements. The number of mainline general traffic lanes is required for all highway-related project types including on-ramp and auxiliary lanes. Do not enter auxiliary lanes or additional ramp lanes here since these are assumed to be one lane additions - this section is only for mainline lanes. Also, note that Cal-B/C does not allow the user to "phase in" the construction. For example, you cannot construct one lane by Year 1 and another by Year 7. Such a scenario must be analyzed as separate projects.
- *Number of HOV Lanes* – Similar to general traffic lanes, if HOV lanes are present or they are going to be added.
- *HOV Restriction* – If HOV lanes exist, then the user must input the restriction. The HOV restriction is the minimum number of vehicle occupants in a vehicle. The model only accepts a “2” for a two-person carpool restriction, or a “3” when at least three or more people must be present in a carpool.
- *Exclusive ROW (Right-of-Way) for Buses* – Used if the section contains an exclusive ROW for buses, commonly known as a busway or bus lanes. In Cal-B/C an exclusive ROW for buses means that no vehicles other than buses can travel on the lane. This would exclude, for example, the El Monte busway in the Los Angeles area where 3+ carpools also can travel on the lanes. The model only accepts an “N” for “No” or a “Y” for “Yes”. This distinction is used by Cal-B/C to evaluate the emissions impacts of busways.
- *Highway Free-Flow Speed* – Design speed for the section. The design speed is often the legal posted speed. The user inputs the existing free-flow speed, and the model assumes that the “New” or future free-flow speed is the same. If the new speed is different from the existing speed, then the user can override the assumed speed by simply typing over the speed in the appropriate cell.

NEW

- *Ramp Design Speed* - Used for on-ramp, off-ramp, and auxiliary lane projects. In the case of auxiliary lanes, this speed should be entered as the average estimated speed experienced on the auxiliary lane while accelerating (in the case of an on-ramp), merging, or decelerating. As with the highway free-flow speed, the user can override the "new" or speed as appropriate.
- *Length* – The length in miles of the section under analysis. There are two "lengths" that must be accounted for:
  - *Highway Segment* – the project design length.
  - *Affected Area* – the distance upstream of the highway segment affected by improvements to the highway segment. The model assumes an affected length based on the project type based on the most recent research. If the project is an auxiliary lane or off-ramp project the assumed distance is 1,500 feet or .28 miles. Freeway connector or HOV operational improvement projects assume an affected length of 3,250 feet or .62 miles, while passing lane projects assumed a length of 3 miles plus the highway segment length. All other projects assume that that the affected area is the same distance as the project design length. As with other model estimates, the user can override any data if better data is available.

Average Daily Traffic (ADT) contains the user inputs for highway general traffic lane (i.e., mainline) volumes for the "current" year, the first year after the project has been constructed or implemented (Year 1), and 20-years into the future. Note that the forecast year is the project opening date plus 20 years, and not the current date plus 20 years.

The user inputs the current year and forecast (20-year) ADT for the "w/o Project" (i.e., the "Without Project" or "No Build") case. The model calculates the "Base (Year 1)" value in the "without project" column. The model uses straight-line interpolation to estimate the Year 1 volume from the current year volume and the Year 20 volume, and the model also estimates the "with (w/) Project" case. Of course, the user can override any of the estimates with better data if it is available.

The Results sheet has an option to include induced demand in the evaluation. If "Y" for "Yes" is selected, the model calculates the change in consumer surplus associated with the excess traffic in the with project scenario compared to the without project scenario. For transit projects, Cal-B/C assumes that highway demand is inelastic (i.e., no induced demand occurs).

Average Hourly HOV Traffic (if HOV lanes) requires that the user enter in current year average hourly HOV volumes for the segment in question, but only if there is an HOV lane present.

NEW

Percent Traffic in Weave estimates the percent of the highway section that is impacted by an operational improvement for both the "without project" and "with project" scenarios. Remember that in Cal-B/C, an operational improvement is a project of one of the following types: Auxiliary lane, freeway or HOV connectors, HOV drop ramp, and on/off-ramp widening. Therefore, the model attempts to estimate how many general traffic lanes are affected by weaving. The table below shows the estimated percent of traffic affected by weaving for these types of projects:

Auxiliary Lane	2 lanes (100% if 1 lane)
On/Off-ramp	3 lanes (100% if <3 lanes)
Freeway Connector	2.5%
HOV Connector/Drop-lanes	4%

Percent Trucks (including Recreational Vehicles) is the percentage of trucks in the traffic flow (i.e., percent of ADT). The model assumes the statewide average of 9 percent. The user can update this value if better data is available. Caltrans' Traffic and Vehicle Data Systems in the Division of Traffic Operations publishes the *Annual Average Daily Truck Traffic on the California State Highway System*. This yearly report, often referred to as the "Truck Volumes Book", provides truck estimates and counts for different locations around the state.

Truck Speed is the average speed of slow moving vehicles such as trucks or recreational vehicles on a grade when there is no passing lane. An entry is required for passing lane projects, but this input is only needed for the base or "without project" scenario. Cal-B/C calculates the automobile speed based on the volume/capacity relationships provided in the most recent Highway Capacity Manual.

NEW

On-Ramp Volume is used for auxiliary lane and on-ramp widening projects and is similar to the Average Daily Traffic input cells, except average hourly volumes are entered rather than daily volumes. Input is required for the peak hour and the average non-peak hour. For auxiliary lanes, Cal-B/C uses this data to estimate the volume of traffic affected by weaving, while for on-ramp widening projects the data is used to evaluate the effectiveness of ramp metering. If the project is a ramp metering strategy without widening the on-ramp, then no entry needs to be made.

The user can override the default values made by Cal-B/C, but the model assumes a peak period volume of 1,350 vehicles per hour for auxiliary lanes, and 800 vehicles per hour for on-ramps.

NEW

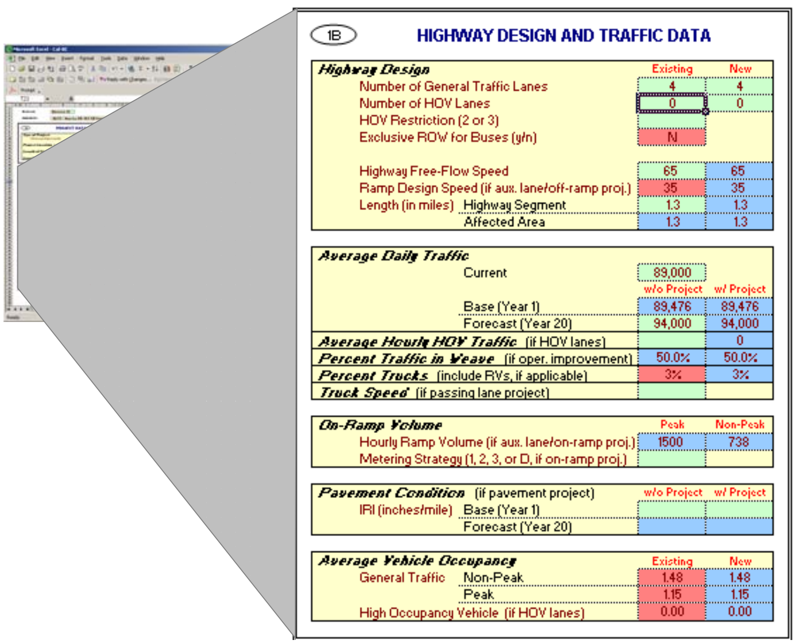
Metering Strategy is required for on-ramp widening projects where there is ramp metering. The model requires a "1", "2", or "3" to indicate the number of vehicles allowed per green signal. A "D" indicates dual metering. If the project is a ramp metering strategy without widening the on-ramp, then no entry needs to be made.

NEW

Pavement Condition for the base year (Year 1) for pavement rehabilitation projects. The user inputs the International Roughness Index (IRI) with and without the project. Cal-B/C will calculate Year 20 values using standard parameters, but the user can override the Year 20 IRI value if better information is available.

Average Vehicle Occupancy uses default values provided by the most recent Statewide Travel Survey. However, since many regions of the state have more updated data, the user can override the default or projected values.

Exhibit 4: Project Information - 1B, Highway Design & Traffic Data



PROJECT EXAMPLE STEP 2: Highway Design and Traffic Data

Now move to the *Highway Design and Traffic Data* section of the project information worksheet (Exhibit 4).

(1) **Highway Design**.

a. *General Traffic Lanes* - Assume that the mixed-flow mainline lanes parallel to the auxiliary lane project is equal to four (4) lanes. Since this project is only on one side of the freeway, the four lanes are the number of lanes in the direction of travel. Make sure that the "New" number of lanes is the same as the "Existing" number since the auxiliary lane addition is assumed by Cal-B/C to be one lane (A mixed-flow lane addition project requires that the "New" number of lanes be greater than the "Existing" number).

b. *HOV Lanes and HOV Restriction* - Assume no HOV lanes in the direction of the project, and you can therefore ignore the corresponding HOV restriction.

c. *ROW for Buses* – Again, assume no bus lanes alone this section.

d. *Free-flow Speed* - Set the free-flow speed to 65 mph. The blue cell for the "New" project free-flow speed will be set automatically to the "Existing" free-flow speed. The blue color of the cell indicates that you may override this speed.

e. *Ramp Design Speed* – Assume this is the default value of 35 mph. Since we are going to the auxiliary lane is fairly long (1.3 miles), you might assume a higher speed, but in general the acceleration and deceleration of vehicles merging onto and off of the mainline lanes causes the speeds along an auxiliary lane to be well below mainline speeds except under congested conditions.

f. *Length* – The project length is 1.3 miles. This is the length of the constructed lane. This is a relatively long auxiliary lane, but it serves 3 interchanges.

g. *Affected Area* – This is a case where engineering judgment needs to be called into play. Cal-B/C assumes that auxiliary lanes have an affected distance (i.e., merging area) of approximately 1,500 feet, based on the Highway Capacity Manual. However, in our example the auxiliary lane covers 3 interchanges with extensive weaving and merging. Therefore, assume that the affected area is the length of the project of 1.3 miles.

(2) **Average Daily Traffic**. Enter the existing average daily traffic into the cell labeled "Current." Use a value of 89,000 for this exercise. Also, enter a value of 94,000 vehicles per day for the forecast year. The model calculates the "Base (Year 1)" value in the "without project" column.

Note: The *Results* sheet has an option to include induced demand in the evaluation. If "Y" for "Yes" is selected, the model calculates the change in consumer surplus associated with the excess traffic in the with project scenario compared to the without project scenario. For a transit project, Cal-B/C assumes that highway demand is inelastic (i.e., no induced demand occurs).

(3) **Average Hourly HOV Traffic**. Update these cells <u>only</u> if this is an HOV project. As with the average daily traffic cells, these cells require the "without project" number of HOV lanes and the future number of HOV lanes when the project is completed. The model assumes that all lanes are constructed by Year 1.

(4) **Percent Trucks**. Enter a 3 percent truck composition of the traffic stream here. The model assumes a 9 percent truck composition for both the "with" and "without" project scenarios, but let's assume the smaller 3 percent.

(5) **Truck Speed**. We do not need this information for our project.

(6) **On Ramp Volume** – Assume an hourly volume of 1,500 vehicles per hour for the auxiliary lane during the peak period. Let the model estimate the off-peak volume.

(7) **Pavement Condition** – Since this is not a pavement project, you can ignore this section.

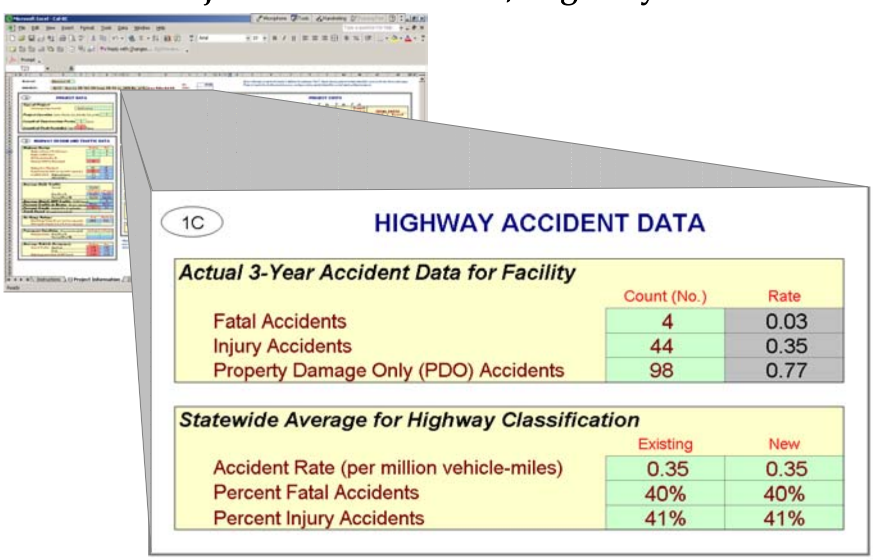
(8) **Average Vehicle Occupancy (AVO)**. This is the average number of people per vehicle on the highway. Let us use the model default (from the 1991 Statewide Travel Survey) of 1.48 for the non-peak AVO and 1.15 for the peak AVO for the "Existing" scenario.

4.1C Highway Accident Data

This section calculates accident rates for the highway facility as shown in Exhibit 5. Accident rates are estimated for fatalities, injuries, and property damage only accidents. For transit projects, the "Count" column contains default values based on statewide averages. For highway projects, the user should override these values with data specific to the segment. The accident rate column, highlighted in gray, is calculated and should not be edited. The calculated value is simply the annualized count divided by millions of vehicle miles (average daily traffic x segment length x 365 days/1,000,000).

The statewide average data comes from The *2000 Accident Data on California State Highways (road miles, travel, accident rates)*. The percent fatal and injury accidents comes from the “Basic Accident Rate Tables” section of that report. The percent rates is provided in tables for three types of roadway: highways, intersections, and ramps.

Exhibit 5: Project Information - 1C, Highway Accident Data


1C HIGHWAY ACCIDENT DATA

Actual 3-Year Accident Data for Facility	Count (No.)	Rate
Fatal Accidents	4	0.03
Injury Accidents	44	0.35
Property Damage Only (PDO) Accidents	98	0.77

Statewide Average for Highway Classification	Existing	New
Accident Rate (per million vehicle-miles)	0.35	0.35
Percent Fatal Accidents	40%	40%
Percent Injury Accidents	41%	41%

PROJECT EXAMPLE STEP 3: Highway Accident Data

Now move to the *Highway Accident Data* section (Section 1C) of the Project Information worksheet (Exhibit 5). Cal-B/C has the statewide averages already entered in the model. Assume, however, that we have some highway accident data and projections available for our project.

(1) In the **Actual 3-Year Accident Data for Facility** cells, assume there were 4 fatal accidents on the parallel highway corridor over the past three years, 44 injury accidents, and 98 property damage only accidents.

(2) Insert statewide average accident rates per million vehicle-miles for road classifications similar to the existing and proposed facilities. This information can be found in the m the *2000 Accident Data on California State Highways*. In that compendium, there are a series of tables called the "Basic Average Accident Rate" tables, which provide statewide average rates for highways, intersections, and ramps.

In our example, assume that our section most closely resembles a "Rural, On-Ramp, Loop without Left Turn" ramp type. This ramp type has a statewide average accident rate along for our section of 0.85. This same ramp type has a fatality percentage rate of 1 percent and a percent of injury accidents of 40.2%. Enter these into Cal-B/C in the appropriate places as shown in Exhibit 5. The model uses adjustment factors (the ratio of actual rates to statewide rates for existing facility) to estimate accident rates, by accident type, for new road classifications. The Model Inputs worksheet presents the results, which the user can edit.

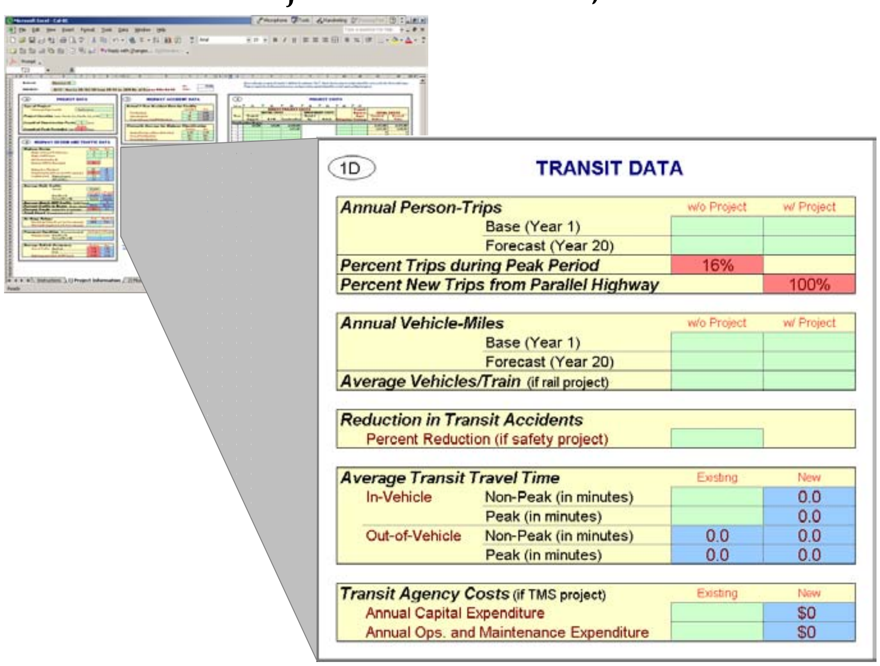
4.1D Transit Data

This section of the project information sheet is used only for transit projects. For transit projects, the user must enter seven additional data items into the model:

- Annual person-trips
- Percent of person-trips occurring during the peak period
- Percent of new person-trips that are from the parallel highway
- Annual vehicle-miles
- Average vehicles per train (if it is a rail project)
- Reduction in transit accidents due to the project (if it is a safety project)
- Average transit travel time (including transfers and wait times).

Exhibit 6 shows the transit data input section of the project information sheet.

Exhibit 6: Project Information - 1D, Transit Data



Annual Person Trips. Contains the user inputs for passenger trips for the "current" year, the first year after the project has been implemented (Year 1), and 20-years into the future. Note that the forecast year is the project completion date plus 20 years, and not the current date plus 20 years.

The user inputs the current year and forecast (20-year) trips for the "w/o Project" case. The model calculates the "Base (Year 1)" value. The model uses straight-line interpolation to estimate the Year 1 volume from the current year volume and the Year 20 volume. The model also estimates the "w/ Project" case. For a transit TMS project, enter only person-trips on affected routes. If the routes are substantially different, the benefits analysis should be split into pieces.

Percent during Peak Period. This is where you estimate the ratio of peak period to daily ridership.

Percent New Trips from Parallel Highway. Typically, improved transit attract some new trips from parallel highways. In practice, the percentage of new transit trips coming from highways falls somewhere between 50 and 80 percent.

Annual Vehicle Miles. This is the number of vehicle-miles operated on the transit line each year.

Average Vehicles per Train. The number of train cars that will be used on an average train consist during the day. This is used to estimate emissions.

Reduction in Transit Accidents. For safety projects, this is the percent reduction in transit accidents expected to occur due to the project.

NEW

Average Transit Travel Time. Transit travel time has two components: In-vehicle time and out of vehicle time. In-vehicle time is the time spent in the bus or train traveling to your destination. Out-of-vehicle time is the time spent walking or driving to the transit stop or station and the time waiting for the bus or train to arrive. Research indicates that passengers value their time waiting at transit stops much more than they value their in-vehicle time. Cal-B/C requires that the user to enter peak and non-peak periods for the existing and new facilities.

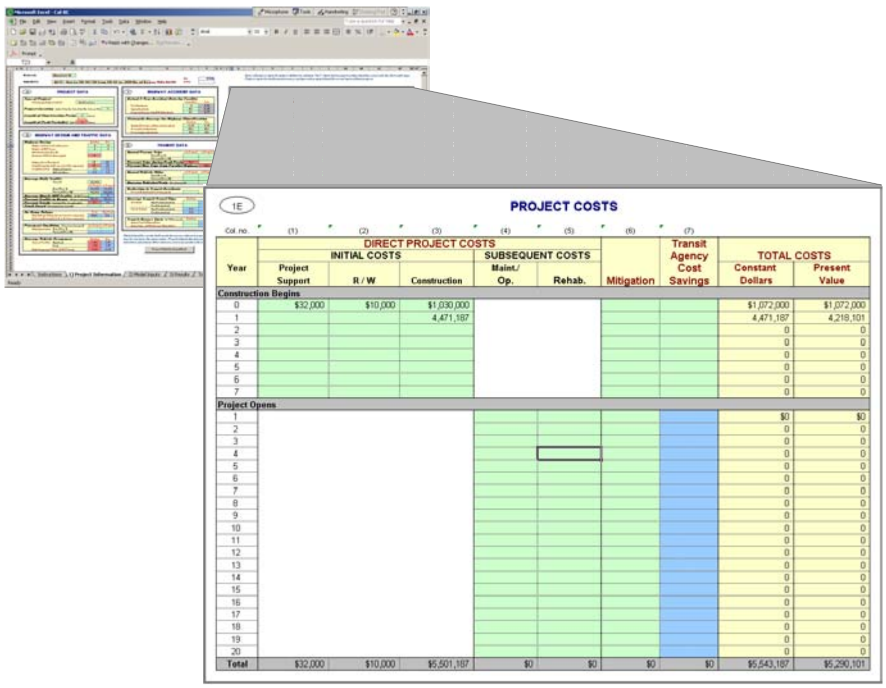
For TMS Projects, insert the average for all transit routes impacted. Cal-B/C assumes new is same as existing for most projects, except signal priority and bus rapid transit projects reduce travel time.

Transit Agency Costs. For TMS projects, Cal-B/C requires that the user input annual capital, operating, and maintenance expenditures for routes impacted by project. The model calculates cost reductions for the new expenditures due to transit TMS. Agency cost savings are estimated automatically as a negative cost.

4.1E Project Cost Data

The user enters project construction, operating, mitigation, and other costs in this section of the project information worksheet. All costs are the incremental costs to provide that project. Incremental costs are the difference between costs with the project and the costs without the project. The project costs worksheet contains seven columns for users to enter cost information as shown in Exhibit 7. Three other columns list the project year and sum the costs.

Exhibit 7: Project Information - 1E, Project Costs



1E

PROJECT COSTS

Year	DIRECT PROJECT COSTS – INITIAL COSTS – Project Support (1)	R / W (2)	Construction (3)	SUBSEQUENT COSTS – Maint./ Op. (4)	Rehab. (5)	Mitigation (6)	Transit Agency Cost Savings (7)	TOTAL COSTS – Constant Dollars	Present Value
Construction Begins									
0	$32,000	$10,000	$1,030,000					$1,072,000	$1,072,000
1			4,471,187					4,471,187	4,218,101
2								0	0
3								0	0
4								0	0
5								0	0
6								0	0
7								0	0
Project Opens									
1								$0	$0
2								0	0
3								0	0
4								0	0
5								0	0
6								0	0
7								0	0
8								0	0
9								0	0
10								0	0
11								0	0
12								0	0
13								0	0
14								0	0
15								0	0
16								0	0
17								0	0
18								0	0
19								0	0
20								0	0
Total	$32,000	$10,000	$5,501,187	$0	$0	$0	$0	$5,543,187	$5,290,101

Insert estimated mitigation costs (e.g., wetlands, community, soundwalls) in constant (Year 2000) dollars during construction and for 20 years after construction completion.

Year

The first column is the project year starting with Year 0, the current year. The model assumes that the project needs no more than seven years to complete the construction. Following the construction period, the project opens and there are twenty (20) years during the project operating period. Year 1 (Base Year) described in the previous sections is represented by the "1" under the "Project Opens" header. Year 20 (Forecast

Year) is represented by the last row on this data entry form. For each row in the section (i.e., each row in the spreadsheet), the user enters the anticipated costs for the year in current year dollars. The model automatically calculates the sum and present value.

Direct Project Costs

Initial costs include:

- Project support (e.g., engineering design and management costs)
- Right-of-Way (R/W) acquisition costs
- Construction costs.

Notice that the project incurs no initial project costs after the project opens. Cal-B/C assumes that all construction funding has been spent by opening day of the project. Furthermore, it is important to note that the user cannot exceed the number of years of construction entered in Section 1A of the project information worksheet. If the user does not enter the construction costs correctly, the model prompts the user for the correct information in the whole zone under subsequent costs. This is illustrated in Exhibit 7.

Subsequent Costs are costs incurred after the project has been constructed and opened for service. These costs include:

- Maintenance and operating costs
- Rehabilitation costs (e.g., pavement overlay, vehicle, track, or station refurbishment).

The user enters estimated future incremental maintenance/operating and rehabilitation costs in constant dollars. These figures should be entered in the years after the project opens.

Mitigation

Mitigation costs include costs to protect the environment and communities from the negative impacts of transportation projects. These costs include wetlands and community preservation as well as soundwalls to reduce highway or rail transit noise. The user enters these costs in constant dollars during construction and for 20 years after construction or implementation has been completed.

Transit Agency Cost Savings

This column is calculated automatically by the model. This cost element represents the cost savings to a transit agency due to efficiency improvements. For example, signal prioritization projects will speed up bus services, reducing operating hours, resulting in reduced labor and other operating costs.

Total Costs

The remaining two columns are calculated by the model automatically. These two columns include the project cost in constant dollars and the net present value for each year. Each column is summarized at the bottom of the section. The following formula calculates the net present value:

$$\text{Net Present Value} = \frac{\text{FutureValue (in constant dollars)}}{\left(1 + \text{Real Discount Rate}\right)^{\text{Year}}}$$

PROJECT EXAMPLE STEP 3: Project Cost Data

This is the final data entry step required to perform a basic analysis. Users with project-specific information can change any parameter within the model. Please refer to the technical supplement for a more detailed discussion of the model assumptions. Let us continue with our analysis.

(1) Enter the **Initial Project Costs**. Enter the project costs for Years 0 and 1 as shown in Exhibit 7. If you do not, input cost data for each year that you indicated in "Length of Construction Period" cell in the "Project Data" (Section 1A) of this worksheet. For example, if you entered 2 years as the length of construction, then you must enter in project costs for Year 0 and Year 1. If you fail to enter cost data the worksheet will provide a warning message for you.

(2) Now look at the years after the project has been constructed and is open for service. In our project, we could allocate funding to operate and maintain the project. However, since this is an auxiliary lane over a short distance, we will assume that the incremental costs to maintain and operate the lane are minimal. For example, the 4 mainline lanes and the on- and off-ramps along the section have to be maintained already. The incremental cost to maintain the additional lane is therefore small.

(3) Before reviewing the results of the model, please review the work done to this point. In the project cost section, you should have a total project cost of $5.54 million with a net present value of $5.29 million.

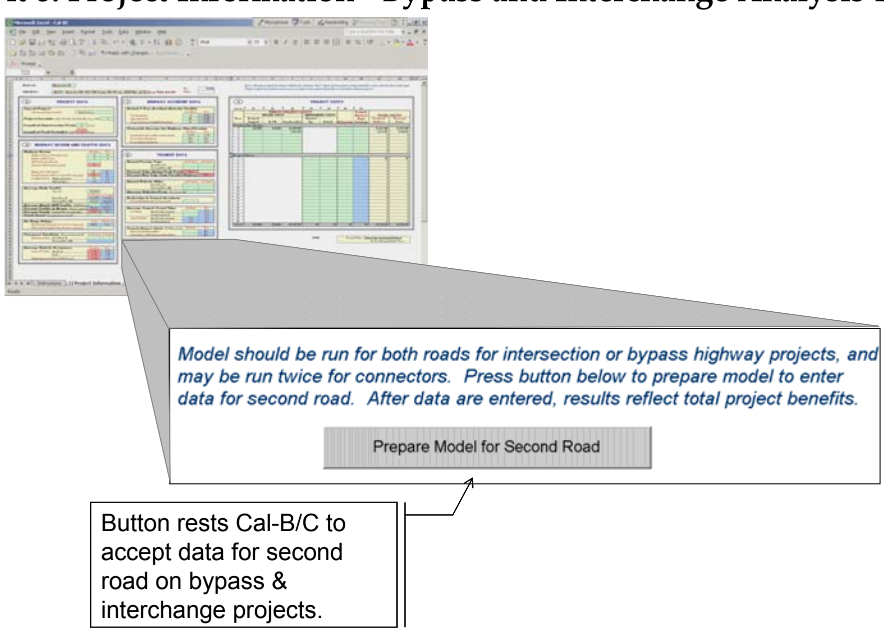
4.1F Bypass and Interchange Projects

Bypass and interchange projects require the user to enter two sets of highway data, since two roads are involved. The model calculates benefits for the first road before user enters information about the second road. The user clicks the button shown in Exhibit 8. The button then clears the Project Information worksheet to receive information for the second road. Only use the button for bypass and interchange projects. If the user clicks this button for any other type of project, the user must re-open the model and begin the analysis again.

For interchange projects, the button simply clears the highway information box, so that traffic and highway geometric data can be entered for the other (intersecting road). For bypass projects, the model zeros the highway information under the existing/without project column and calculates the with project column traffic on the bypass road as the without project traffic minus the project traffic on the existing roads. The user only needs to enter the highway geometric information (e.g., number of lanes, etc.). For bypass projects, the model automatically changes the green and blue box colors in the highway information box so the user knows what data to enter. For both types of projects, the model retains accident data for the second road, but the user can change this if data specific to second road are available.

After entering data for the first road, the user should check the speeds and volumes in the Model Inputs sheet. The user should return to the Project Information sheet to click the button. It is important to note that the model cannot calculate induced demand for bypass projects.

Exhibit 8: Project Information - Bypass and Interchange Analysis Button



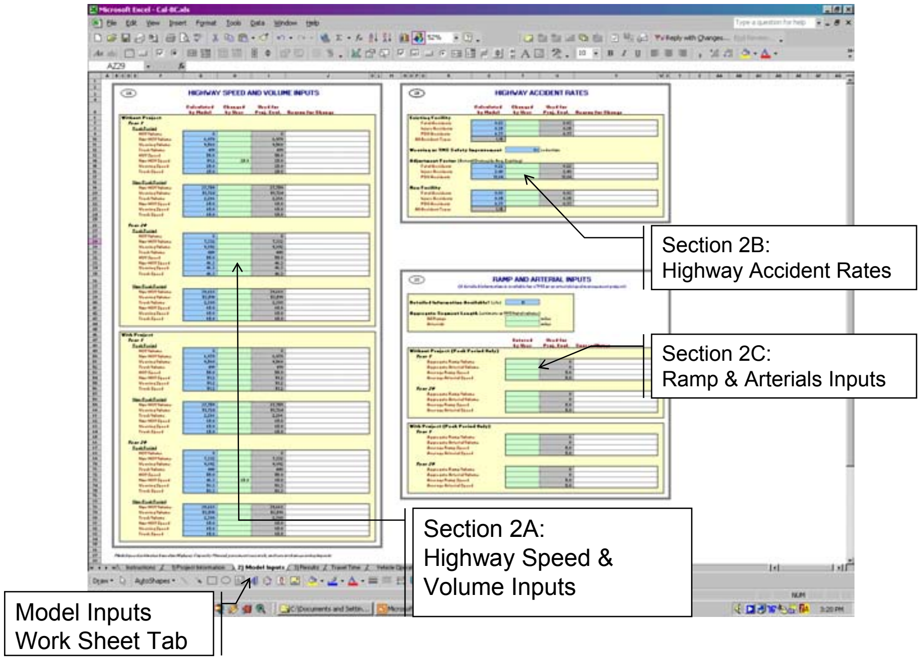
4.2 Model Inputs Worksheet

The model inputs worksheet (Exhibit 9) allows the user to override many of the values used to perform the benefit-cost analysis. Many projects have more in-depth data available, such as the output of a regional travel demand model or micro-simulation results for a TMS project. In these cases, the user should override the Cal-B/C defaults. The model provides three sections in the model inputs worksheet for doing this. Several items are contained within these three sections:

- Highway Speed and Volume Inputs
  - Peak and non-peak periods
  - HOV, non-HOV, weaving, and truck volumes
  - HOV, non-HOV, weaving, and truck speeds
- Highway Accident Rates and adjustment factors (existing and new facilities)
  - Fatal accidents
  - Injury accidents
  - Property damage only (PDO) accidents.
- Ramp and Arterial Inputs
  - Aggregate ramp or arterial
  - Injury accidents
  - Property damage only (PDO) accidents.

The sheet shows the model estimate and provides a space for the user to change the value without disrupting the model defaults. There is also a space provided to input an explanation for the change.

Exhibit 9: Model Inputs Sheet



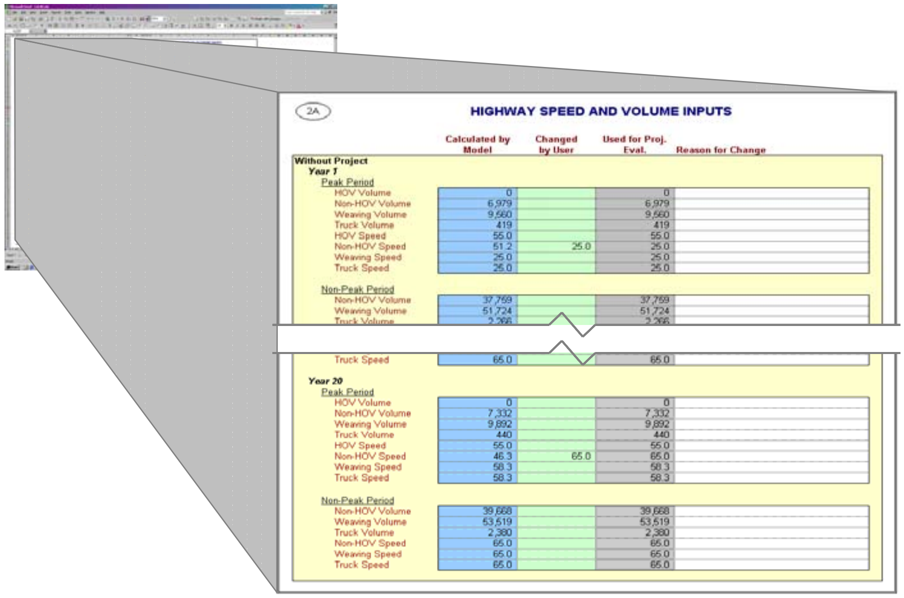
For example, Cal-B/C forecasts accident rates with the project by calculating the ratio of current accident rates to the statewide average found in the accident data book published by the Traffic Operations Program. If a particular stretch of highway has accident rates above the statewide average, the model will forecast accident rates with project also above the average.

If the project is designed to lower accident rates to the statewide average, the user must manually override the value calculated by the model by changing the accident adjustment factor. The model assumes (through the adjustment factor) that the differential remains the same for the new facility. The user can change this factor to 1.0 if the user thinks that the project will result in accident rates at the statewide average for the facility type. The user can control this calculation separately for fatal accidents, injury accidents, and Property Damage Only (PDO) accidents.

PROJECT EXAMPLE STEP 3: Project Cost Data

We have completed the *Project Information Worksheet*, but assume for our example that we have observed current speeds and future speed data from a regional travel demand model. Assume we have speed data for the mainline lanes as shown in Exhibit 10. Let's assume that our mainline (Non-HOV) lanes have a peak speed of 25 mph in the current year, but that we expect this speed to improve to 65 mph with the project by year 20.

Exhibit 10: Model Inputs - 2A, Update Speed and Volume Inputs


2A

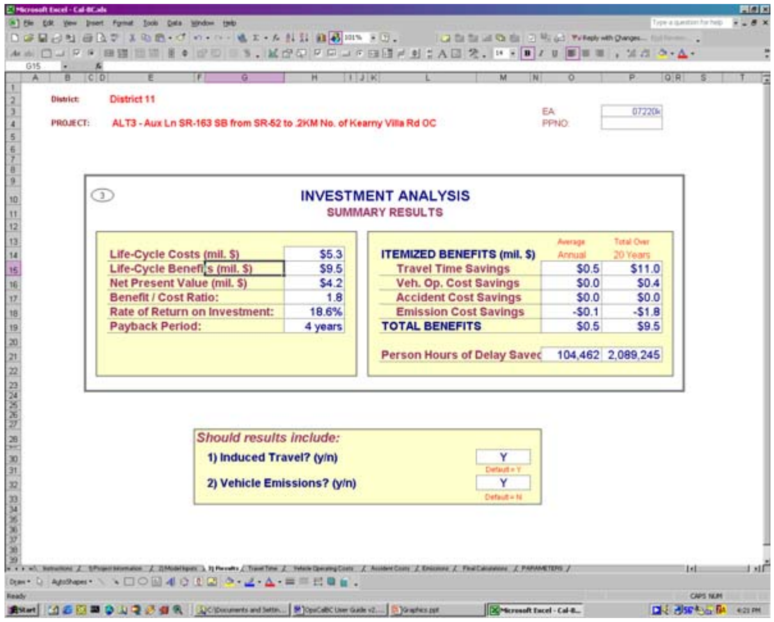
HIGHWAY SPEED AND VOLUME INPUTS

	Calculated by Model	Changed by User	Used for Proj. Eval.	Reason for Change
Without Project				
Year 1				
Peak Period				
HOV Volume	0		0	
Non-HOV Volume	6,979		6,979	
Weaving Volume	9,560		9,560	
Truck Volume	419		419	
HOV Speed	55.0		55.0	
Non-HOV Speed	51.2	25.0	25.0	
Weaving Speed	25.0		25.0	
Truck Speed	25.0		25.0	
Non-Peak Period				
Non-HOV Volume	37,759		37,759	
Weaving Volume	51,724		51,724	
Truck Volume	2,266		2,266	
Truck Speed	65.0		65.0	
Year 20				
Peak Period				
HOV Volume	0		0	
Non-HOV Volume	7,332		7,332	
Weaving Volume	9,892		9,892	
Truck Volume	440		440	
HOV Speed	55.0		55.0	
Non-HOV Speed	46.3	65.0	65.0	
Weaving Speed	58.3		58.3	
Truck Speed	58.3		58.3	
Non-Peak Period				
Non-HOV Volume	39,668		39,668	
Weaving Volume	53,519		53,519	
Truck Volume	2,380		2,380	
Non-HOV Speed	65.0		65.0	
Weaving Speed	65.0		65.0	
Truck Speed	65.0		65.0	

4.3 Results Worksheet

The final worksheet covered in this User's Guide is the *Results Worksheet*. This is where the user finds the outputs from Cal-B/C. Exhibit 11 shows an example of this output. Note that the Results worksheet asks for an additional input, and that input is to determine if the project will induce demand (i.e., additional travel in the with project case compared to the without project case). If the user selects "Y", then Cal-B/C uses an econometric technique (change in consumer surplus) to value induced demand. Selecting "Y" for emissions calculates net air quality benefits. The default is "N." If either of these toggles is changed for bypass or interchange projects, then the change should be made before the button is pushed to prepare the model for the other road.

Exhibit 11: Results Worksheet - Final Model Output



Cal-B/C summarizes the analysis results on a per-project basis using several measures:

- Life-cycle costs (in $ million)
- Life-cycle benefits (in $ million)
- Net present value (in $ million)
- Benefit/cost ratio (benefits/costs)
- Rate of return on investment (in percentage return/year)
- Project payback period (in years).

The model calculates these results over the life of the project, which is assumed twenty years. In addition, Cal-B/C displays annualized and life-cycle user benefits.

Life-Cycle Costs are the present values of all net project costs, including initial and subsequent costs in real current dollars.

Life-Cycle Benefits are the sum of the present value benefits for the project.

Net Present Value equals the Life-Cycle Benefits minus the Life-Cycle Costs. The value of benefits exceeds the value of costs for a project with a positive net present value.

Benefit/Cost Ratio shows the benefits relative to the costs of a project. A project with a benefit/cost ratio greater than one has a positive economic value.

Rate of Return on Investment is the discount rate at which benefits and costs are equal. For a project with a Rate of Return greater than the Discount Rate, benefits are greater than costs, and the project has a positive economic value. The Rate of Return on Investment allows the user to compare projects with different costs, different benefit flows, and different times.

Payback Period is the number of years it takes for the net benefits (benefits minus costs) to equal, or payback, the initial construction costs. For a project with a Payback Period longer than the life-cycle of the project, initial construction costs are not recovered. The Payback period varies inversely with the Benefit-Cost Ratio: shorter Payback Period yields higher Benefit-Cost.

PROJECT EXAMPLE STEP 3: Project Cost Data

The project input has been completed, we have double-checked our data, and we are ready to review the results. Having completed the data entry means that we have completed the *Project Information* worksheet and the *Model Inputs* worksheet. The results are shown in the investment analysis summary (Exhibit 11).

You are now ready to use Cal-B/C to model standard highway and transit improvement projects. For more information about how Cal-B/C estimates particular impacts, please see the technical supplement to the user's manual.

APPENDIX: ADDITIONAL PROJECT EXAMPLES

Example A: Passenger Rail Improvement Project Example

Open the *Project Information* sheet to begin an analysis. Exhibit A1 shows the *Project Data* section for a passenger rail improvement project. Green cells are cells that require data input. The red cells provide default values that the user can change.

Exhibit A1: Project Information Worksheet Section 1A

1A **PROJECT DATA**

Type of Project		
Select project type from list	Passenger Rail	
Project Location (enter 1 for So. Cal., 2 for No. Cal., or 3 for rural)	1	
Length of Construction Period	2	years
	Existing	
Length of Peak Period(s) (up to 8 hrs)	5	hours

1) **Type of Project**. Select the "Passenger Rail" project type.

2) **Project Location**. This cell requires you to enter a "1" for Southern California urban areas, a "2" for Northern California urban areas, or a "3" for rural areas in order to determine emissions benefits for the project. Assume that our project is being built in Southern California, and put a "1" in this cell. This cell tells the model which emissions tables to reference in the Emissions worksheet.

3) **Length of Construction Period**. Enter the amount of time needed to construct the project. Assume that our rail project will be completed in 2 years. The model evaluates project impacts only after the project is built. For example, a project begun in 2000 that takes five years to complete would not cause any impacts until year 2005 when the project opens. The Year 1 impacts occur immediately after the project opens. The Year 20 impacts would occur in 2024 for this hypothetical project. Cal-B/C uses this cell to determine the economic impacts. This number must be a whole number. For example, a project that will take 8 months to construct should be entered as the number "1" representing one year. A project taking 2 years and 5 months can be rounded down to 2 years or up to three years, at the user's discretion, but must be consistent with the cost data entered.

4) **Length of Peak Period**. For our project, enter a "5" in this cell to represent a five-hour total daily peak travel period (include both AM and PM peak periods). The model allows the user to evaluate up to an eight (8) hour daily peak period. Cal-B/C calculates peak hour traffic by multiplying a statewide average peak-hour percent traffic by the number of peak hours. In Cal-B/C this is calibrated to five hours. Peak periods greater than eight (8) hours will produce erroneous results. The user must adjust the length of the peak period and the percent ADT in a typical peak hour (entered in Parameters sheet) for projects with peak periods longer than 8

hours. The peak period helps convert average daily traffic volumes into average peak and non-peak volumes and speeds. Speed is an important variable to determine travel time savings, fuel consumption, and emissions.

Now move to the *Highway Design and Traffic Data* section of the project information worksheet (Exhibit A2).

Exhibit A2: Project Information Worksheet Section 1B

1B **HIGHWAY DESIGN AND TRAFFIC DATA**

Highway Design		Existing	New
Number of General Traffic Lanes		6	6
Number of HOV Lanes			
HOV Restriction (2 or 3)			
Exclusive ROW for Buses (y/n)		N	
Highway Free-Flow Speed		55	55
Ramp Design Speed (if aux. lane/off-ramp proj.)		35	35
Length (in miles)	Highway Segment	50.0	50.0
	Affected Area	50.0	50.0

Average Daily Traffic			
	Current	130,000	
		w/o Project	w/ Project
	Base (Year 1)	143,124	143,124
	Forecast (Year 20)	267,800	267,800
Average Hourly HOV Traffic (if HOV lanes)			0
Percent Traffic in Weave (if oper. improvement)			
Percent Trucks (include RVs, if applicable)		9%	9%
Truck Speed (if passing lane project)			

On-Ramp Volume	Peak	Non-Peak
Hourly Ramp Volume (if aux. lane/on-ramp proj.)	0	0
Metering Strategy (1, 2, 3, or D, if on-ramp proj.)		

Pavement Condition (if pavement project)		w/o Project	w/ Project
IRI (inches/mile)	Base (Year 1)		
	Forecast (Year 20)		

Average Vehicle Occupancy		Existing	New
General Traffic	Non-Peak	1.48	1.48
	Peak	1.38	1.38
High Occupancy Vehicle (if HOV lanes)		0.00	0.00

5) **Highway Design**. Assume that the highway parallel to the rail project has six (6) general traffic lanes and no HOV lanes in both directions (i.e., three lanes per direction) Set the free-flow speed to 55 mph. Make sure that the "New" number of lanes is the same as the "Existing" number. Otherwise, the model will not produce the correct results for this rail project (A lane addition project requires that the "New" number of lanes be greater than the "Existing" number). The model does not allow the user to "phase in" the construction. For example, you cannot construct one lane by Year 1 and another by Year 7. Such a scenario must be analyzed as separate projects.

The blue cell for the "New" project free-flow speed will be set automatically to the "Existing" free-flow speed. The blue cell indicates that you may override this speed if you determine that the free-flow speed in the forecast year is different from the current free-flow speed.

The *Length* cells determine the distance that the project will influence. In our example, assume that the project is an interregional rail project along a 50-mile corridor. The *Affected Area* only applies to passing lane and operational improvement projects. This is because adding a truck climbing or passing lane not only improves traffic flow on the segment where the lane is located, but also affects traffic upstream of the new lane.

6) **Average Daily Traffic**. Enter the existing average daily traffic into the cell labeled "current." Use a value of 130,000 for this exercise. Also, enter a value of 267,800 vehicles per day for the forecast year. Note: The forecast year is the project opening date plus 20 years, NOT the current date plus 20 years.

   The model calculates the "Base (Year 1)" value in the "without project" column. The model uses straight-line interpolation to estimate the Year 1 volume from the current year volume and the Year 20 volume. If you have data that are more accurate for Year 1, you can override the values calculated by the model.

   Notice that the "without project" and "with project" scenario volumes are the same for the passenger rail project. The model requires the user to assume a constant volume for highway demand, UNLESS demand on the highway is expected to increase because of the rail project. We take the shift from highway to rail into account when we input the transit information. The model will correctly calculate the benefits associated with mode shifts to rail although it is not apparent on this input screen.

   Note: The *Results* sheet has an option to include induced demand in the evaluation. If "Y" for "Yes" is selected, the model calculates the change in consumer surplus associated with the excess traffic in the with project scenario compared to the without project scenario. For a transit project, Cal-B/C assumes that highway demand is inelastic (i.e., no induced demand occurs).

7) **Average Hourly HOV Traffic**. Update these cells <u>only</u> if this is an HOV project. As with the average daily traffic cells, these cells require the "without project" number of HOV lanes and the future number of HOV lanes when the project is completed. The model assumes that all lanes are constructed by Year 1.

8) **Percent Trucks**. Enter the percent truck composition of the traffic stream here. The model assumes a nine (9) percent truck composition for both the "with" and "without" project scenarios.

9) **Truck Speed**. We do not need this information for our passenger rail project. For passing lane projects, trucks travel this speed on a grade when there is no passing lane. Cal-B/C calculates the automobile speed based on the volume and capacity of the roadway using volume/capacity relationships provided in the most recent Highway Capacity Manual. Trucks may have a much slower speed on grades where a passing lane project is to be constructed. Leave this cell empty for our project.

10) **Average Vehicle Occupancy (AVO)**. This is the average number of people per vehicle on the highway. Let us use the model default (from the 1991 Statewide Travel Survey) of 1.48 for the non-peak AVO and 1.38 for the peak AVO for the "Existing" scenario. Assume a slight reduction in AVO in the "New" scenario to 1.41 in the off-peak and 1.31 in the peak as travelers use transit more.

The model has the statewide averages already entered in Exhibit A3. Assume, however, that we have some highway accident data and projections available for our project.

Exhibit A3: Project Information Worksheet Section 1C

1C **HIGHWAY ACCIDENT DATA**

Actual 3-Year Accident Data for Facility	Count (No.)	Rate
Fatal Accidents	2	0.00
Injury Accidents	35	0.00
Property Damage Only (PDO) Accidents	50	0.01

Statewide Average for Highway Classification	Existing	New
Accident Rate (per million vehicle-miles)	0.80	0.56
Percent Fatal Accidents	2%	1%
Percent Injury Accidents	32%	33%

11) In the **Actual 3-Year Accident Data for Facility** cells, assume there were two (2) fatal accidents on the parallel highway corridor over the past three years, 35 injury accidents, and 50 property damage only accidents.

12) Insert statewide average accident rates per million vehicle-miles for road classifications similar to the existing and proposed facilities. Include Base Rate and ADT factors, where applicable. Also, insert statewide percent of accidents that are fatal and injury accidents for road classifications similar to existing and proposed facilities. The model uses adjustment factors (the ratio of actual rates to statewide

rates for existing facility) to estimate accident rates, by accident type, for new road classifications. The Model Inputs worksheet presents the results, which the user can edit.

For our project, assume that overall accident rates will decline because of reduced congestion on the roadway (from 0.80 to 0.56). Also assume fatal accidents will decline from 2% to 1% and injury accidents will increase from 32% to 33%.

Here, as shown in Exhibit A4, is where we do most of our data entry for our rail project. Assume that we are implementing a project to improve train safety, travel times, and frequency of service. Such a project may require some right-of-way improvements, signaling improvements, and additional passenger train cars.

Exhibit A4: Project Information Worksheet Section 1D

1D **TRANSIT DATA**

Annual Person-Trips		w/o Project	w/ Project
	Base (Year 1)	310,000	400,000
	Forecast (Year 20)	460,000	600,000
Percent Trips during Peak Period		60%	
Percent New Trips from Parallel Highway			65%
Annual Vehicle-Miles		w/o Project	w/ Project
	Base (Year 1)	532,000	740,000
	Forecast (Year 20)	532,000	740,000
Average Vehicles/Train (if rail project)		3	4
Reduction in Transit Accidents			
Percent Reduction (if safety project)		5%	
Average Transit Travel Time		Existing	New
In-Vehicle	Non-Peak (in minutes)	50.0	50.0
	Peak (in minutes)	45.0	45.0
Out-of-Vehicle	Non-Peak (in minutes)	15.0	15.0
	Peak (in minutes)	10.0	10.0
Transit Agency Costs (if TMS project)		Existing	New
Annual Capital Expenditure			$0
Annual Ops. and Maintenance Expenditure			$0

13) **Annual Person Trips**. As in step 3, when we entered average daily traffic for the parallel highway, we input base year (Year 1) and forecast year (Year 20) estimates for transit demand. Input the demand data as shown in Exhibit A4.

14) **Percent during Peak Period**. This is where you estimate the ratio of peak period to daily ridership. In our example, assume that 60% of all transit trips on the line will occur during the five-hour peak period.

15) **Percent New Trips from Parallel Highway**. Typically, improved passenger rail services attract some new trips from parallel highways. In practice, the percentage of new transit trips coming from highways falls somewhere between 50% and 80%.

Let us assume that our new line will bring 65% of its new passengers from the highway in question.

16) **Annual Vehicle Miles**. This is the number of vehicle-miles operated on the passenger rail line per year. Assume 532,000 revenue miles for Years 1 and 20 in the "without project" scenario and 740,000 for the "with project" scenario.

17) **Average Vehicles per Train**. Enter the number of train cars that will be used on an average train consist during the day. In our example, we assume that each train will add an average of 1 car per train during the day increasing from three (3) cars in the "without project" scenario to four (4) for our new project. This means that some trains may have three cars, but others may have 5 or more per consist depending on the demand.

18) **Reduction in Transit Accidents**. If you are building a safety project, enter the percent reduction in transit accidents that you expect to occur due to the project. Assume that this project includes grade-crossing improvements to increase vehicle and pedestrian safety, and we anticipate a 5% reduction in train incidents.

19) **Average Transit Travel Time**. This is where you enter the average travel time required to make a trip on transit. The transit travel time represents the total travel time by transit and includes the waiting time for the transit vehicle, transfer times, and the in-transit time. Enter the values as shown in Exhibit A4.

20) **Transit Agency Costs**. Since there is no Transportation Management System (TMS) component to this project, leave this section blank. For TMS projects, however, Cal-B/C requires that the user input annual capital, operating, and maintenance expenditures for routes impacted by project. The model calculates cost reductions for the new expenditures due to transit TMS. Agency cost savings are estimated automatically as a negative cost.

Now we are at the final data entry step required to perform a basic analysis. Users with project-specific information can change any parameter within the model. Please refer to the technical supplement for a more detailed discussion of the model assumptions. Let us continue with our analysis. Exhibit A5 shows the data that we will enter for this project.

Exhibit A5: Project Information Worksheet Section 1E

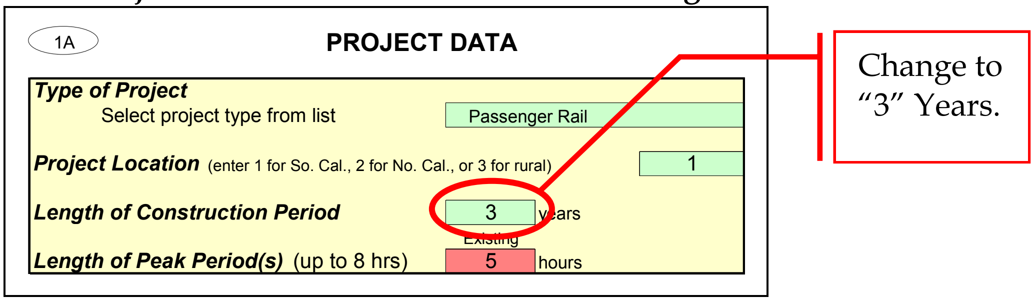
1E

PROJECT COSTS

Col. no.	(1)	(2)	(3)	(4)	(5)	(6)	(7)		
	DIRECT PROJECT COSTS						Transit Agency Cost Savings	TOTAL COSTS	
	INITIAL COSTS			SUBSEQUENT COSTS					
Year	Project Support	R / W	Construction	Maint./ Op.	Rehab.	Mitigation		Constant Dollars	Present Value
Construction Begins									
0	$500,000	$4,000,000	$6,000,000			250,000		$10,750,000	$10,750,000
1	400,000		12,750,000			500,000		13,650,000	12,877,358
2	200,000		12,750,000	Adjust Construction Period		800,000		13,750,000	12,237,451
3								0	0
4								0	0
5								0	0
6								0	0
7								0	0
Project Opens									
1				$175,000				$175,000	$155,749
2				175,000				175,000	146,933
3				175,000				175,000	138,616
4				175,000				175,000	130,770
5				175,000				175,000	123,368
6				175,000				175,000	116,385
7				175,000				175,000	109,797
8				175,000				175,000	103,582
9				175,000				175,000	97,719
10				175,000	2,000,000			2,175,000	1,145,763
11				175,000				175,000	86,970
12				175,000				175,000	82,047
13				175,000				175,000	77,403
14				175,000				175,000	73,021
15				175,000				175,000	68,888
16				175,000				175,000	64,989
17				175,000				175,000	61,310
18				175,000				175,000	57,840
19				175,000				175,000	54,566
20				175,000	2,500,000			2,675,000	786,866
Total	$1,100,000	$4,000,000	$31,500,000	$3,500,000	$4,500,000	$1,550,000	$0	$46,150,000	$39,547,392

21) Enter the **Initial Project Costs**. Enter the project costs for Years 0 through 2 as shown in Exhibit A5. Note the error message received after entering the data for Year 2. It says, "Adjust Construction Period" (Look at the white space under the "SUBSEQUENT COST" columns). Our construction dollars are being spent over three years, yet we indicated in Section 1A of the Project Information worksheet that construction would last only two years. Go back to the Project Information sheet and make the change as shown in Exhibit A6 below.

Exhibit A6: Project Information Worksheet Correcting Section 1A



22) Now look at the years after the project has been constructed and is open for service. In our project, we will have to allocate funding to operate and maintain the project. These project maintenance and operating costs are the incremental costs required to operate the additional service, not the costs to operate the total service on that alignment. If we were to increase service on an existing rail line, we would subtract the cost required to operate the current route (i.e., the "without project" scenario) from the cost to operate the "with project" scenario.

23) Before reviewing the results of the model, please review the work done to this point. In the project cost section, you should have a total project cost of $46.15 million with a net present value of $39.3 million.

We have completed the *Project Information Worksheet*, but assume for our example that we have additional volume information from a regional travel demand model. In particular, we have more detailed estimates of peak and off-peak volumes. In the Model Inputs sheet, the average daily volume is broken out into peak and non-peak volumes as shown in Exhibit A7

Exhibit A7: Model Inputs Worksheet Section 2A

2A

HIGHWAY SPEED AND VOLUME INPUTS

	Calculated by Model	Changed by User	Used for Proj. Eval.	Reason for Change
Without Project				
Year 1				
Peak Period				
HOV Volume	0		0	
Non-HOV Volume	52,806	55,446	55,446	
Weaving Volume	0		0	
Truck Volume	5,223	5,484	5,484	
HOV Speed	55.0		55.0	
Non-HOV Speed	46.8		46.8	
Weaving Speed	55.0		55.0	
Truck Speed	46.8		46.8	
Non-Peak Period				
Non-HOV Volume	82,594	79,954	79,954	
Weaving Volume	0		0	
Truck Volume	8,169	7,907	7,907	
Non-HOV Speed	55.0		55.0	
Weaving Speed	55.0		55.0	
Truck Speed	55.0		55.0	
Year 20				
Peak Period				
HOV Volume	0		0	
Non-HOV Volume	95,042	99,794	99,794	
Weaving Volume	0		0	
Truck Volume	9,400	9,870	9,870	
HOV Speed	55.0		55.0	
Non-HOV Speed	10.3		10.3	
Weaving Speed	55.0		55.0	
Truck Speed	10.3		10.3	
Non-Peak Period				
Non-HOV Volume	148,656	143,904	143,904	
Weaving Volume	0		0	
Truck Volume	14,702	14,232	14,232	
Non-HOV Speed	54.8		54.8	
Weaving Speed	55.0		55.0	
Truck Speed	54.8		54.8	
With Project				
Year 1				
Peak Period				
HOV Volume	0		0	
Non-HOV Volume	52,736	55,373	55,373	
Weaving Volume	0		0	
Truck Volume	5,223	5,484	5,484	
HOV Speed	55.0		55.0	
Non-HOV Speed	46.9		46.9	
Weaving Speed	55.0		55.0	
Truck Speed	46.9		46.9	
Non-Peak Period				
Non-HOV Volume	82,551	79,914	79,914	
Weaving Volume	0		0	
Truck Volume	8,169	7,907	7,907	
Non-HOV Speed	55.0		55.0	
Weaving Speed	55.0		55.0	
Truck Speed	55.0		55.0	
Year 20				
Peak Period				
HOV Volume	0		0	
Non-HOV Volume	94,934	99,681	99,681	
Weaving Volume	0		0	
Truck Volume	9,400	9,870	9,870	
HOV Speed	55.0		55.0	
Non-HOV Speed	10.3		10.3	
Weaving Speed	55.0		55.0	
Truck Speed	10.3		10.3	
Non-Peak Period				
Non-HOV Volume	148,588	143,842	143,842	
Weaving Volume	0		0	
Truck Volume	14,702	14,232	14,232	
Non-HOV Speed	54.8		54.8	
Weaving Speed	55.0		55.0	
Truck Speed	54.8		54.8	

24) In our **Without Project Peak Period** section type 55,446 in the "Changed by User" field for the Year 1 Non-HOV volume and 5,484 in the truck volume cell (This represents a 2% reduction in volumes as estimated by Cal-B/C. Fill in the remaining cells in the "Changed by User" field in Exhibit .

NOTE: The total volume in the "Used for Proj. Eval." field for each section should equal the total volume on the highway.

The project input has been completed, we have double-checked our data, and we are ready to review the results. Having completed the data entry means that we have completed the *Project Information* worksheet and the *Model Inputs* worksheet. The results are shown in the investment analysis summary (Exhibit A8).

Exhibit A8: Results Worksheet Section 3

3

INVESTMENT ANALYSIS

SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$39.3
Life-Cycle Benefits (mil. $)	$44.2
Net Present Value (mil. $)	$4.8
Benefit / Cost Ratio:	1.1
Rate of Return on Investment:	7.2%
Payback Period:	12 years

ITEMIZED BENEFITS (mil. $)	Average Annual	Total Over 20 Years
Travel Time Savings	$0.6	$12.1
Veh. Op. Cost Savings	$0.4	$8.1
Accident Cost Savings	$1.2	$24.0
Emission Cost Savings	$0.0	$0.0
TOTAL BENEFITS	$2.2	$44.2
Person Hours of Delay Saved	162,511	3,250,214

Should results include:

1) Induced Travel? (y/n)	Y Default = Y
2) Vehicle Emissions? (y/n)	N Default = N

Example B: Arterial Signal Management Project Example

Exhibit B1: Project Information Worksheet Section 1A

1A **PROJECT DATA**

Type of Project		Complete only sections 1A, 1E, and 2C	
Select project type from list		Arterial Signal Management	
Project Location (enter 1 for So. Cal., 2 for No. Cal., or 3 for rural)			2
Length of Construction Period	1	years	
	Existing		
Length of Peak Period(s) (up to 8 hrs)	4	hours	

1) **Type of Project**. Select the "Arterial Signal Management" project type.

2) **Project Location**. This cell requires you to enter a "1" for Southern California urban areas, a "2" for Northern California urban areas, or a "3" for rural areas in order to determine emissions benefits for the project. Assume that our project is being built in Northern California, and put a "2" in this cell. This cell tells the model which emissions tables to reference in the Emissions worksheet.

3) **Length of Construction Period**. Enter the amount of time needed to construct the project. Assume that our arterial signal upgrade project will be completed in 1 year. The model evaluates project impacts only after the project is built. For example, a project begun in 2000 that takes five years to complete would not cause any impacts until year 2005 when the project opens. The Year 1 impacts occur immediately after the project opens. The Year 20 impacts would occur in 2024 for this hypothetical project. Cal-B/C uses this cell to determine the economic impacts. This number must be a whole number. For example, a project that will take 8 months to construct should be entered as the number "1" representing one year. A project taking 2 years and 5 months can be rounded down to 2 years or up to three years, at the user's discretion, but must be consistent with the cost data entered.

4) **Length of Peak Period**. For our project, enter a "4" in this cell to represent a four-hour total daily peak travel period (include both AM and PM peak periods). The model allows the user to evaluate up to an eight (8) hour daily peak period. Cal-B/C calculates peak hour traffic by multiplying a statewide average peak-hour percent traffic by the number of peak hours. In Cal-B/C this is calibrated to five hours. Peak periods greater than eight (8) hours will produce erroneous results. The user must adjust the length of the peak period and the percent ADT in a typical peak hour (entered in Parameters sheet) for projects with peak periods longer than 8 hours. The peak period helps convert average daily traffic volumes into average peak and non-peak volumes and speeds. Speed is an important variable to determine travel time savings, fuel consumption, and emissions.

Now move to the *Highway Design and Traffic Data* section of the project information worksheet (Exhibit B2).

Exhibit B2: Project Information Worksheet Section 1B

1B

HIGHWAY DESIGN AND TRAFFIC DATA

Highway Design		Existing	New
Number of General Traffic Lanes		6	6
Number of HOV Lanes			
HOV Restriction (2 or 3)			
Exclusive ROW for Buses (y/n)		N	
Highway Free-Flow Speed		35	35
Ramp Design Speed (if aux lane/off-ramp proj)		35	35
Length (in miles)	Highway Segment	1.3	1.3
	Affected Area	1.3	1.3

Average Daily Traffic			
	Current	52,000	
		w/o Project	w/ Project
	Base (Year 1)	53,300	53,300
	Forecast (Year 20)	78,000	78,000
Average Hourly HOV Traffic (if HOV lanes)			0
Percent Traffic in Weave (if oper. improvement)			
Percent Trucks (include RVs, if applicable)		2%	2%
Truck Speed (if passing lane project)			

On-Ramp Volume	Peak	Non-Peak
Hourly Ramp Volume (if aux lane/on-ramp proj)	0	0
Metering Strategy (1, 2, 3, or D, if on-ramp proj)		

Pavement Condition (if pavement project)		w/o Project	w/ Project
IRI (inches/mile)	Base (Year 1)		
	Forecast (Year 20)		

Average Vehicle Occupancy		Existing	New
General Traffic	Non-Peak	1.48	1.48
	Peak	1.38	1.38
High Occupancy Vehicle (if HOV lanes)		0.00	0.00

5) **Highway Design**. In this example, our arterial has project has six (6) general traffic lanes. Set the free-flow speed to 35 mph, which is the posted speed. Make sure that the "New" number of lanes is the same as the "Existing" number. Otherwise, the model will not produce the correct results.

   The blue cell for the "New" project free-flow speed will be set automatically to the "Existing" free-flow speed. The blue cell indicates that you may override this speed if you determine that the free-flow speed in the forecast year is different from the current free-flow speed.

   The *Length* cells determine the distance that the project will influence. In our example, assume that we are synchronizing the signals along a 1.3 miles corridor. The *Affected Area* only applies to passing lane and operational improvement projects. This is because adding a truck climbing or passing lane not only improves traffic flow on the segment where the lane is located, but also affects traffic upstream of the new lane.

6) **Average Daily Traffic**. Enter the existing average daily traffic shown in Exhibit 1B into the appropriate cells. Note: The forecast year is the project opening date plus 20 years, NOT the current date plus 20 years.

Do not enter anything into the Year 1 cells. Let's have Cal-B/C calculate that information for us. The model calculates the "Base (Year 1)" value in the "without project" column using straight-line interpolation to estimate the Year 1 volume from the current year volume and the Year 20 volume. If you have data that are more accurate for Year 1, you can override the values calculated by the model.

Notice that the "without project" and "with project" scenario volumes are the same for the project. The model requires the user to assume a constant volume for highway demand, UNLESS demand on the highway is expected to increase because of the rail project.

Note: The *Results* sheet has an option to include induced demand in the evaluation. If "Y" for "Yes" is selected, the model calculates the change in consumer surplus associated with the excess traffic in the with project scenario compared to the without project scenario. For a transit project, Cal-B/C assumes that highway demand is inelastic (i.e., no induced demand occurs).

7) **Average Hourly HOV Traffic**. Update these cells only if this is an HOV project. As with the average daily traffic cells, these cells require the "without project" number of HOV lanes and the future number of HOV lanes when the project is completed. The model assumes that all lanes are constructed by Year 1.

8) **Percent Trucks**. Enter the percent truck composition of the traffic stream here as two (2) percent. The model assumes a nine (9) percent truck composition for both the "with" and "without" project scenarios.

9) **Truck Speed**. We do not need this information for our project. For passing lane projects, trucks travel this speed on a grade when there is no passing lane. Cal-B/C calculates the automobile speed based on the volume and capacity of the roadway using volume/capacity relationships provided in the most recent Highway Capacity Manual. Trucks may have a much slower speed on grades where a passing lane project is to be constructed.

10) **Average Vehicle Occupancy (AVO)**. This is the average number of people per vehicle on the highway. Let us use the model default (from the 1991 Statewide Travel Survey) of 1.48 for the non-peak AVO and 1.38 for the peak AVO for the

"Existing" scenario. Assume a slight reduction in AVO in the "New" scenario to 1.41 in the off-peak and 1.31 in the peak as travelers use transit more.

The model has the statewide averages already entered in Exhibit B3. Assume, however, that we have some highway accident data and projections available for our project.

Exhibit B3: Project Information Worksheet Section 1C

1C **HIGHWAY ACCIDENT DATA**

Actual 3-Year Accident Data for Facility	Count (No.)	Rate
Fatal Accidents	0	0.00
Injury Accidents	90	1.16
Property Damage Only (PDO) Accidents	19	0.26

Statewide Average for Highway Classification	Existing	New
Accident Rate (per million vehicle-miles)	2.40	2.40
Percent Fatal Accidents	57%	57%
Percent Injury Accidents	58%	58%

11) In the **Actual 3-Year Accident Data for Facility** cells, assume there were no fatal accidents on the corridor over the past three years, 90 injury accidents, and 19 property damage only (PDO) accidents.

12) Insert statewide average accident rates per million vehicle-miles for road classifications similar to the existing and proposed facilities. This information can be found in the m the *2000 Accident Data on California State Highways*. In that compendium, there are a series of tables called the "Basic Average Accident Rate" tables, which provide statewide average rates for highways, intersections, and ramps. . The model uses adjustment factors (the ratio of actual rates to statewide rates for existing facility) to estimate accident rates, by accident type, for new road classifications. The Model Inputs worksheet presents the results, which the user can edit.

Since we are not adding any transit service, there is no need to enter any information in Section 1D: Transit Data for this arterial project.

Now we are at the final data entry step required to perform a basic analysis. Users with project-specific information can change any parameter within the model. Please refer to the technical supplement for a more detailed discussion of the model assumptions. Let us continue with our analysis. Exhibit B5 shows the data that we will enter for this project.

Exhibit B4: Project Information Worksheet Section 1E

1E

PROJECT COSTS

Col. no.	(1)	(2)	(3)	(4)	(5)	(6)	(7)		
	DIRECT PROJECT COSTS						Transit Agency Cost Savings	TOTAL COSTS	
	INITIAL COSTS			SUBSEQUENT COSTS					
Year	Project Support	R / W	Construction	Maint./ Op.	Rehab.	Mitigation		Constant Dollars	Present Value
Construction Begins									
0		$411,000	$3,869,405					$4,280,405	$4,280,405
1								0	0
2								0	0
3								0	0
4								0	0
5								0	0
6								0	0
7								0	0
Project Opens									
1								$0	$0
2								0	0
3								0	0
4								0	0
5								0	0
6								0	0
7								0	0
8								0	0
9								0	0
10								0	0
11								0	0
12								0	0
13								0	0
14								0	0
15								0	0
16								0	0
17								0	0
18								0	0
19								0	0
20								0	0
Total	$0	$411,000	$3,869,405	$0	$0	$0	$0	$4,280,405	$4,280,405

13) Enter the **Initial Project Costs**. Enter the project costs for Year 0 as shown in Exhibit B5. Assume there are no subsequent costs to this arterial management system. Remember that the subsequent costs are the incremental costs to maintain the system over the old system. Since the new system is similar to the old system in that it's simply replacing old signals with new and old controllers with new, let's assume that the incremental costs of maintenance and rehabilitation are zero.

We have completed the *Project Information Worksheet*. However, arterial management projects require the user to input travel speed differences due to the project in the Model Input worksheet in order to show net benefits. Assume for our example that we have additional volume and speed information from. In the Model Inputs sheet in Section 2C, input the data as shown in Exhibit B7.

Exhibit B5: Model Inputs Worksheet Section 2C

2C

RAMP AND ARTERIAL INPUTS

(if detailed information is available for a TMS or an arterial signal management project)

Detailed Information Available? (y/n) Y

Aggregate Segment Length (estimate as VMT/total volume)

All Ramps		miles
Arterials	1.3	miles

	Entered by User	Used for Proj. Eval.	Source/Notes
Without Project (Peak Period Only)			
Year 1			
Aggregate Ramp Volume		0	
Aggregate Arterial Volume	11,615	11,615	
Average Ramp Speed		5.0	
Average Arterial Speed	15.0	15.0	
Year 20			
Aggregate Ramp Volume		0	
Aggregate Arterial Volume	18,649	18,649	
Average Ramp Speed		5.0	
Average Arterial Speed	12.0	12.0	
With Project (Peak Period Only)			
Year 1			
Aggregate Ramp Volume		0	
Aggregate Arterial Volume	11,615	11,615	
Average Ramp Speed		5.0	
Average Arterial Speed	16.4	16.4	
Year 20			
Aggregate Ramp Volume		0	
Aggregate Arterial Volume	18,649	18,649	
Average Ramp Speed		5.0	
Average Arterial Speed	13.1	13.1	

The project input has been completed, we have double-checked our data, and we are ready to review the results. Having completed the data entry means that we have completed the *Project Information* worksheet and the *Model Inputs* worksheet. The results are shown in the investment analysis summary (Exhibit B8).

Exhibit B6: Results Worksheet Section 3

3

INVESTMENT ANALYSIS

SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$4.3
Life-Cycle Benefits (mil. $)	$56.0
Net Present Value (mil. $)	$51.7
Benefit / Cost Ratio:	13.1
Rate of Return on Investment:	102.3%
Payback Period:	2 years

ITEMIZED BENEFITS (mil. $)	1st Year	20 Years
Travel Time Savings	$3.6	$49.3
Veh. Op. Cost Savings	$0.4	$6.7
Accident Reductions	$0.0	$0.0
Emission Reductions	$0.0	$0.0
TOTAL BENEFITS	$4.0	$56.0

Should results include:

1) Induced Travel? (y/n)	Y Default = Y
2) Vehicle Emissions? (y/n)	N Default = N